American Welding Society
Safety and Health
Fact Sheet No. 38 September 2013
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Respiratory Protection Basics for Welding Operations

RESPIRATORY HAZARDS

Welding fume is a complex mixture of very small particles of metal oxides and other compounds that are released during the welding process. Fume ingredients depend on the make-up of the electrode (stick, wire or filler rod), the base metal, surface coatings and contaminants. The type of shielding used (flux vs. gas) is also important. In addition, when electrode coatings, fluxes, shielding gases and surface coatings are burned or exposed to arc radiation, they may give off gases that could be harmful, such as carbon monoxide, ozone, nitrogen oxides, gaseous fluoride and phosgene.

What are the Hazards from Overexposure?

It is claimed that overexposed welders have a greater chance of developing bronchitis, airway irritation, lung function changes, lung infections (pneumonia), and lung cancer when compared to the general working population. Welding and its allied processes can result in overexposures to some forms of manganese in fumes from specific types of welding consumables. Some of these have been reported to cause a neurological impairment known as manganism.

How Can Welders Be Protected from Overexposure?

- **Understand Exposures:** To protect welders it is necessary to understand their actual exposures. The amount of welding fume and other contaminants given off is influenced by many variables. For example, the fume given off increases as current or electrode feed rate increases. Also, fume generation is typically much higher for flux-shielded processes than for gas-shielded processes. The amount of fume being given off is only one factor affecting the amount of fume a welder might inhale. Because so many things are involved, it is difficult to estimate the exposure level for welders. Therefore, when adequate ventilation is in doubt, exposure tests should be conducted to measure actual representative exposures during welding operations. Exposure tests typically involve the collection of air samples by a qualified safety specialist, such as a Certified Industrial Hygienist. Because each component of welding fume has unique

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effects and exposure limits, the exposure level of each component must be measured separately. For example, exposure tests for stainless steel welders usually focus on chromium and nickel. (More information on welding fume and exposure assessment is listed at the end of this document.)

- **Exposure Limits:** Once the exposure is measured and understood, it can be compared to exposure limits set up to protect workers. Occupational exposure limits are typically given as a time-weighted average concentration over a normal eight-hour workday (8-hour TWA). In the USA, OSHA's published Permissible Exposure Limits (PELs) are the legally enforceable standard. However, many choose to follow more current advisory standards such as Threshold Limit Values (TLVs®) published by the American Conference of Governmental Industrial Hygienists (ACGIH). Each contaminant measured must be compared to its exposure limits to judge if exposure levels pose a risk or not.

- **Ventilation and Engineering Controls:** Normally, ventilation, or exhaust, or both can be used to keep fumes and gases from the breathing zone and general area. When this doesn't work and exposure limits are exceeded, it is necessary to take additional steps. These could include the use of: fume exhaust guns, additional ventilation devices, fans or even simple adjustments relative to the natural air flow.

- **Keep Away from the Plume (fume):** One important factor is the position of the welder's head relative to the rising smoke/plume and how well the ventilation keeps the plume away from the welder's breathing zone and general area. Take care to position the work and/or ventilation device to maintain protection at all times.

When to Use Respiratory Protection?

Whenever possible, ventilation systems or other controls should be used to remove harmful fumes and gases. However, these may not reduce exposure levels enough. Then in this case another option may be to use a respirator. Various respirators exist that offer their own benefits and limitations. A summary of common welding respirator categories is shown in Table 2.

How is the Correct Filter Selected?

Particulate (Dust) Filters: Fume can only be captured with particulate filters. Table 1 lists particle filter classifications defined by the National Institute for Occupational Safety and Health (NIOSH). Always look for the NIOSH mark and classification code when choosing a particulate filter.

Table 1

Efficiency	Resistance to oil mist		
	N-Series (not resistant)	R-Series (medium resistance)	P-Series (high resistance)
95%	**N95**	**R95**	**P95**
99%	**N99**	**R99**	**P99**
99.97%	**N100**	**R100**	**P100**

The first letter refers to the filter's resistance to liquid oil mist. The number

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Table 2					
	Disposable Half Facepiece	Elastomeric Half Facepiece	Powered-Air, Loose-Fitting Headpiece	Powered-Air, Helmet (Hard Hat)	Supplied-Air, (Loose-Fitting or Helmet)
Description					
APF	10	10	25	25 / 1000 *	25 or 1000
Benefits	No maintenance Low unit cost Fits under any welding helmet Light weight	More filter options More size options Moderate unit cost Light weight	Reduced stuffiness Cooling effect No breathing resistance No fit testing Hard hat options Accommodates limited facial hair	Same as Loose-Fitting Headpiece plus: Hard hat included Higher protection factor Better neck protection Accommodates facial hair including some beards	Maximum contaminant versatility Chilled or heated air No breathing resistance No filters to change No batteries to charge
Limitations	Not compatible with facial hair For particles only Increase heat retention and stuffiness Fit-test required	Not compatible with facial hair May not fit all welding helmets Increase heat retention and stuffiness Fit-test required	Increased weight Higher unit cost Increased maintenance Increased user training	Same as Loose-Fitting Headpiece	Attachment to airline Increased weight Higher unit cost Requires compressor

*APF refers to Assigned Protection Factor which is *the minimum anticipated level of protection provided by each type of respirator worn in accordance with an adequate respiratory protection program. For example, an APF of 10 means that the respirator should reduce the airborne concentration of a particulate by a factor of 10 (or to 10% of the workplace concentration).* August 2006 OSHA amended 29 CFR 1910.134 by *adding requirements for APF's. For Powered Air Purifying (PAPR) helmets, the manufacturer must have a Workplace Protection Factor(WPF) or Simulated Workplace Protection Factor (SWPF) study data to substantiate APF of 1000. Refer to OSHA Final Rule: http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=FEDERAL_REGISTER&p_id=18846*

that follows refers to the filter's efficiency in laboratory tests. N95 class filters are recommended for most welding applications because welding fume is relatively easy to filter and oil mist is seldom a factor. There is no harm in using a higher class filter, provided the worker is fit-tested for the device and medically cleared. When high hazard compounds, such as lead or cadmium are involved, special regulations require the use of P100 class filters. Particulate filters must be replaced when they become soiled, damaged or difficult to breathe through.

Gas and Vapor Cartridges: Gases and vapors cannot be removed by particulate (dust) filters. They must be removed by adsorption in a bed of activated carbon or other media, depending on the gas or vapor species. Certain vapors must be changed before they can be captured. This is accomplished by treating activated carbon with catalysts. Therefore, it is important to select a cartridge that is approved by NIOSH for the vapors present. The approved contaminants will

be listed on each cartridge label. The most common cartridges used in welding are organic vapor (black label), acid gas (white label) and organic vapor/acid gas (yellow label). The service life (how long it lasts) of gas and vapor cartridges depends on the chemicals removed and their concentration. Gas and vapor cartridges do not clog like particle filters. They simply become used up and allow contaminants to flow through. In some cases, harmful levels can be exceeded without being detected. Therefore, it is critical that a service life estimate be calculated for each situation. Establish a schedule that tells when to change filters. Respirator manufacturers can help with figuring this schedule.

Powered Air Purifying Respirators (PAPRs): Battery powered respirators use a motor to pull air through filters and/or cartridges to purify the air. The blowers are usually belt-mounted and push filtered air through a headpiece breathing tube. Because the filtered air is under pressure, leakage of contaminants into the helmet is greatly reduced. This increases the level of protection. The movement of air helps keep the welder cool and comfortable.

Supplied Air Respirators: Some gases and vapors cannot really be filtered. In these cases, a supplied-air respirator may be needed. Supplied-air respirators require a compressor, located in a clean area, to pump clean air into the respirator. The main disadvantage of supplied-air respirators is that the airline makes it difficult for the wearer to move. An important advantage of supplied-air is the ability to cool the air. This is a popular feature in hot welding environments. (Supplied-air must come from a device or system that can supply what is known as "Grade D" breathing air. General shop compressed air often contains contaminants and should not be used.)

Other Factors

- Individual comfort is important. An uncomfortable respirator will be worn less consistently. Removal of the respirator, even for short periods of time, dramatically reduces the protection.

- Welders with facial hair must shave or use a particular type of powered or supplied air respirator. Even one-day stubble can cause tight fitting respirators to leak significantly.

- Not all respirators are flame and spark resistant. Select a respirator recommended for welding.

Respirator Program

Before respirators can be used in a workplace, the employer must have a written OSHA Respiratory Protection Program in place. Key Elements of the Program Include:

- **Training:** Training must include instruction on respirator use, maintenance, cleaning and storage. Users must be trained prior to use and at least annually thereafter.

- **Medical Evaluation:** Certain lung or heart conditions can make respirator use dangerous. Medical clearance must be obtained before using a respirator.

- **Fit Testing:** The OSHA standard requires fit testing for all tight-fitting

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respirator models. Whether you select a maintenance-free or a reusable respirator, the wearer must obtain a satisfactory fit. Fit tests must be repeated for each model and when any changes occur that could affect the fit.

- **Respirator Selection:** Describes how a respirator was selected for each task.

- **Program Evaluation:** A process for regularly evaluating the effectiveness of the program.

INFORMATION SOURCES

American National Standards Institute (ANSI). Safety in Welding, Cutting, and Allied Processes, Z49.1, available from American Welding Society, 8669 Doral Blvd., Doral, FL 33166. Phone 800-443-9353; Web site: www.aws.org.

American National Standards Institute (ANSI). Safe Practices For Respiratory Protection (ANSI Z88.2), available from ANSI, 11 West 42nd Street, New York, NY 10036-8002; telephone: 212-642-4900; web site: www.ansi.org.

Occupational Safety And Health Administration (OSHA). Code Of Federal Regulations, Title 29 Labor, Chapter XVII, Parts 1901,.1 to 1910.1450, Order No. 869-019-00111-5, available from Superintendent of Documents, U.S. Government Printing Office, Washington, DC 02402.

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